

## CLAIMS

1. A fuel cell system comprising:
  - a proton exchange membrane having a first face and a second face;
  - a cathode catalyst layer overlying the first face of the proton exchange membrane;
  - a cathode diffusion layer overlying the cathode catalyst layer;
  - an anode catalyst layer overlying the second face of the proton exchange membrane;
  - an anode diffusion layer overlying the anode catalyst layer;
  - wherein the cathode diffusion layer has a water vapor permeance of less than about  $3 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere.
2. The fuel cell system of claim 1 wherein the water vapor permeance of the cathode diffusion layer is less than about  $2 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere.
3. The fuel cell system of claim 1 wherein the water vapor permeance of the cathode diffusion layer is less than about  $1.5 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere.
4. The fuel cell system of claim 1 wherein a water vapor permeance of the anode diffusion layer is greater than about  $3 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere.
5. The fuel cell system of claim 1 wherein the water vapor permeance of the cathode diffusion layer is between about 10 and about 50% of a water vapor permeance of the anode diffusion layer.

6. The fuel cell system of claim 1 wherein a thickness of the cathode diffusion layer is less than about 1000 microns.

7. The fuel cell system of claim 6 wherein the thickness of the cathode diffusion layer is in a range of about 150 to about 600 microns.

8. The fuel cell system of claim 7 wherein a thickness of the anode diffusion layer is in a range of about 75 to about 200 microns.

9. The fuel cell system of claim 6 wherein a bulk density of the cathode diffusion layer is less than about 2.0 g/cc.

10. The fuel cell system of claim 9 wherein the bulk density of the cathode diffusion layer is in a range of about 0.4 to about 0.8 g/cc.

11. The fuel cell system of claim 6 wherein a porosity of the cathode diffusion layer is greater than about 25%.

12. The fuel cell system of claim 11 wherein the porosity of the cathode diffusion layer is in a range of about 50% to about 80%.

13. The fuel cell system of claim 6 wherein the cathode diffusion layer contains between about 5 wt% to about 15 wt% polytetrafluoroethylene.

14. The fuel cell system of claim 1 wherein a ratio of a thickness of the cathode diffusion layer to a thickness of the anode diffusion layer is between about 20:1 to about 3:1.

15. The fuel cell system of claim 1 wherein a bulk density of the cathode diffusion layer is less than about 2.0 g/cc.

16. The fuel cell system of claim 15 wherein the bulk density of the cathode diffusion layer is in a range of about 0.4 g/cc to about 0.8 g/cc.

17. The fuel cell system of claim 16 wherein a bulk density of the anode diffusion layer is in a range of about 0.15 g/cc to about 0.5 g/cc.

18. The fuel cell system of claim 15 wherein a thickness of the cathode diffusion layer is less than about 1000 microns.

19. The fuel cell system of claim 18 wherein the thickness of the cathode diffusion layer is in a range of about 150 to about 600 microns.

20. The fuel cell system of claim 15 wherein a porosity of the cathode diffusion layer is greater than about 25%.

21. The fuel cell system of claim 20 wherein the porosity of the cathode diffusion layer is in a range of about 50% to about 80%.

22. The fuel cell system of claim 15 wherein the cathode diffusion layer contains between about 5 wt% to about 15 wt% polytetrafluoroethylene.

23. The fuel cell system of claim 1 wherein a ratio of a bulk density of the cathode diffusion layer to a bulk density of the anode diffusion layer is between about 20:1 and about 1.5:1.

24. The fuel cell system of claim 1 wherein a porosity of the cathode diffusion layer is greater than about 25%.

25. The fuel cell system of claim 24 wherein the porosity of the cathode diffusion layer is in a range of about 50% to about 80%.

26. The fuel cell system of claim 25 wherein a porosity of the anode diffusion layer is in a range of about 70% to about 90%.

27. The fuel cell system of claim 24 wherein a thickness of the cathode diffusion layer is less than about 1000 microns.

28. The fuel cell system of claim 27 wherein the thickness of the cathode diffusion layer is in a range of about 150 to about 600 microns.

29. The fuel cell system of claim 24 wherein a bulk density of the cathode diffusion layer is less than about 2.0 g/cc.

30. The fuel cell system of claim 29 wherein the bulk density of the cathode diffusion layer is in a range of about 0.4 to about 0.8 g/cc.

31. The fuel cell system of claim 24 wherein the cathode diffusion layer contains between about 5 wt% to about 15 wt% polytetrafluoroethylene.

32. The fuel cell system of claim 1 wherein a ratio of a porosity of the cathode diffusion layer to a porosity of the anode diffusion layer is between about 1:3.8 and about 1:1.25.

33. The fuel cell system of claim 1 wherein the cathode diffusion layer contains at least about 0.25 wt% polytetrafluoroethylene.

34. The fuel cell system of claim 33 wherein the cathode diffusion layer contains in a range of about 5 wt % to about 15 wt% polytetrafluoroethylene.

35. The fuel cell system of claim 34 wherein the anode diffusion layer contains in a range of about 3 wt % to about 10 wt% polytetrafluoroethylene.

36. The fuel cell system of claim 33 wherein a thickness of the cathode diffusion layer is less than about 1000 microns.

37. The fuel cell system of claim 36 wherein the thickness of the cathode diffusion layer is in a range of about 150 to about 600 microns.

38. The fuel cell system of claim 33 wherein a bulk density of the cathode diffusion layer is less than about 2.0 g/cc.

39. The fuel cell system of claim 38 wherein the bulk density of the cathode diffusion layer is in a range of about 0.4 to about 0.8 g/cc.

40. The fuel cell system of claim 33 wherein a porosity of the cathode diffusion layer is greater than about 25%.

41. The fuel cell system of claim 40 wherein the porosity of the cathode diffusion layer is in a range of about 50% to about 80%.

42. The fuel cell system of claim 1 wherein the proton exchange membrane remains fully hydrated during operation of the fuel cell system without use of an external cathode hydration system.

43. A fuel cell system comprising: ✓  
a proton exchange membrane having a first face and a second face;  
a cathode catalyst layer overlying the first face of the proton exchange membrane;  
a cathode diffusion layer overlying the cathode catalyst layer;  
an anode catalyst layer overlying the second face of the proton exchange membrane;  
an anode diffusion layer overlying the anode catalyst layer;  
wherein the cathode diffusion layer has a water vapor permeance of less than about  $3 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere, and wherein a thickness of the cathode diffusion layer is less than about 1000 microns, and wherein a bulk density of the cathode diffusion layer is less than about 2.0 g/cc, and wherein a porosity of the cathode diffusion layer is greater than about 25%.

44. The fuel cell system of claim 43 wherein the thickness of the cathode diffusion layer is in a range of about 150 to about 600 microns.

45. The fuel cell system of claim 43 wherein the bulk density of the cathode diffusion layer is in a range of about 0.4 to about 0.8 g/cc.

46. The fuel cell system of claim 43 wherein the porosity of the cathode diffusion layer is in a range of about 50% to about 80%.

47. The fuel cell system of claim 43 wherein the cathode diffusion layer contains in a range of about 5 to about 15 wt% polytetrafluoroethylene.

48. A cathode diffusion layer for a fuel cell system comprising:

a cathode diffusion layer containing less than 15 wt% polytetrafluoroethylene and having a water vapor permeance of less than about  $3 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere.

49. The cathode diffusion layer of claim 48 wherein the water vapor permeance of the cathode diffusion layer is less than about  $2 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere.

50. The cathode diffusion layer of claim 48 wherein the water vapor permeance of the cathode diffusion layer is less than about  $1.5 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere.

51. The cathode diffusion layer of claim 48 wherein a thickness of the cathode diffusion layer is less than about 1000 microns.

52. The cathode diffusion layer of claim 51 wherein the thickness of the cathode diffusion layer is in a range of about 150 microns to about 600 microns.

53. The cathode diffusion layer of claim 48 wherein a bulk density of the cathode diffusion layer is less than about 2.0 g/cc.

54. The cathode diffusion layer of claim 53 wherein the bulk density of the cathode diffusion layer is in a range of about 0.4 to about 0.8 g/cc.

55. The cathode diffusion layer of claim 48 wherein a porosity of the cathode diffusion layer is greater than about 25 %.

56. The cathode diffusion layer of claim 55 wherein a porosity of the cathode diffusion layer is in a range of about 50 % to about 80 %.

57. The cathode diffusion layer of claim 48 wherein the cathode diffusion layer contains in a range of about 5 wt % to about 15 wt % polytetrafluoroethylene.

58. A cathode diffusion layer for a fuel cell system comprising:

a cathode diffusion layer having a water vapor permeance of less than about  $3 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere, and wherein a thickness of the cathode diffusion layer is less than about 1000 microns, and wherein a bulk density of the cathode diffusion layer is less than about 2.0 g/cc, and wherein a porosity of the cathode diffusion layer is greater than about 25 %.

59. The cathode diffusion layer of claim 58 wherein the water vapor permeance of the cathode diffusion layer is less than about  $2 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere.



60. The cathode diffusion layer of claim 58 wherein the water vapor permeance of the cathode diffusion layer is less than about  $1.5 \times 10^{-4}$  g/(Pa s m<sup>2</sup>) at 80°C and 1 atmosphere.

61. The cathode diffusion layer of claim 58 wherein the thickness of the cathode diffusion layer is in a range of about 150 microns to about 600 microns.

62. The cathode diffusion layer of claim 58 wherein the bulk density of the cathode diffusion layer is in a range of about 0.4 to about 0.8 g/cc.

63. The cathode diffusion layer of claim 58 wherein a porosity of the cathode diffusion layer is in a range of about 50% to about 80%.

64. The cathode diffusion layer of claim 58 wherein the cathode diffusion layer contains in a range of about 5 wt % to about 15 wt % polytetrafluoroethylene.